Dressing entangling quantum dot photons

A near-resonant laser coherently interacting with an atomic-like transition generates hybrid matter-field states. While well-established in atomic physics even with single atoms and ions, near-resonant coherent interactions have only recently been demonstrated in a nanostructured artificial atom, such as a semiconductor quantum dot (QD). Nanostructures offer a potentially scalable solution in a number of quantum information applications, and thus coherent control in these systems is particularly desirable. However, the electronic states in QDs are formed from tens of thousands of constituent atoms and the extent of these interactions is not known.

The photoluminescence spectrum of a single InAs QD was recorded as a secondary resonant laser optically dressed either the vacuum-to-exciton or the exciton-to-biexciton transitions. Polarization-resolved measurements reveal splittings of the linearly-polarized fine-structure states that are non-degenerate in an asymmetric QD. These splittings manifest as either triplets or doublets and depend sensitively on laser intensity and detuning. Our approach realizes complete resonant control of a multi-excitonic system in emission, which can be either pulsed or continuous-wave, and offers direct access to the emitted photons.

While QDs maintain remarkable atomic-like two level system characteristics, QDs are not identical and ideal symmetries within a QD exist only by chance. Using these techniques we expect to selectively tailored QD states to create a desired symmetry or electronic level structure. For example, working in the far-detuned (AC Stark) regime, we can create discrete photon-pair entanglement from a QD radiative cascade that would otherwise yield only classically correlated photons. Quantum-state design by coherent optical manipulation would be versatile and deterministic. It would be suitable for a wide variety of QDs and thus could be routinely applied in semiconductor nanostructures.

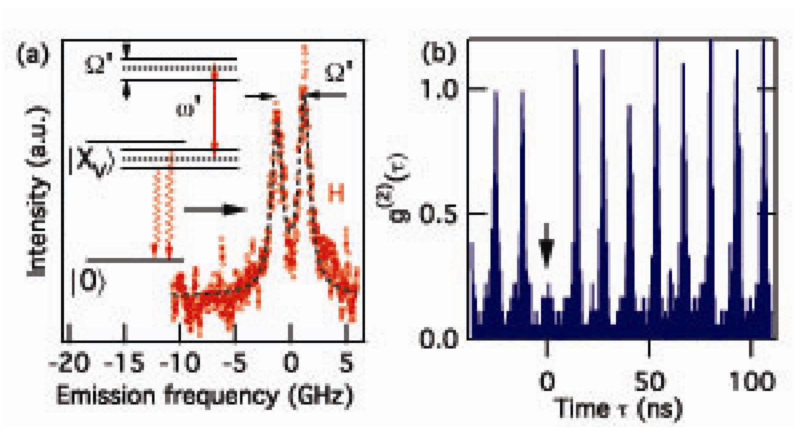

Figure 3.1: Resonant scattering in a single InAs quantum dot (QD) using two lasers. (a) By tuning a laser resonantly to the horizontally polarized biexciton transition of the QD new optical field – exciton states are formed. This modifies the lower horizontally polarized single-exciton state, which is seen as a doublet when an addition above-band laser is applied. (b) The emission reflects the antibunching properties of the QD exciton state and the pulsed above-band laser (13 ns repetition rate).

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